

water, salt and fresh

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It is also in its capacity as a national agency that the department's Water Sector is responsible for coordinating Canada's role in the International Hydrologic Decade. This world-wide research effort, begun in 1965, is delving into the storage and movement of water in all its forms — gaseous, liquid and solid — in, on, or above the earth's surface. Canada alone has some 200 research projects that fall under this heading.

An example of a broad regional study of water potential is that for the lakes and rivers of Northern Ontario. It includes topographic surveys of possible dam sites, drilling and seismic surveys to determine foundation conditions, and surveys to locate suitable construction materials and possible diversion routes. Being carried out with the investigations is a major survey of stream flow and water levels. Other departmental experts survey the present use of and demand for water in that area, ranging from fur trapping to the generation of electricity and recreation. The effects on the water resources of mining and similar activities are also taken into consideration.

Of lasting value to all planners of economic development involving water resources is the permanent water-survey network maintained by the department and dating back more than half a century. It consists of some 2,300 stations measuring water levels, stream flow and sediment transport throughout Canada. Special studies in this field are undertaken from time to time.

Recognizing the valuable additions to knowledge of Canada's water resources that are being made, or can be made, by Canadian universities, the department has established a fund for grants in aid of research in that field. Grants are awarded on the recommendation of the National Advisory Committee on Water Resources Research, and have in recent years totalled nearly half a million dollars per year. University scientists are also provided with ship time aboard departmental vessels for research projects.

More detailed information on various activities mentioned above is available in a number of departmental booklets either in existence or in preparation, and covering such topics as hydrography, oceanography, pollution, water as a resource, opportunities for university graduates with the department, the Canada Water Act, etc.

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the construction of dams, dikes, floodways, reservoirs, diversion channels, etc.

In planning and recommending such efforts, the Department of Energy, Mines and Resources plays an essential and prominent part.

One example of a successful federal-provincial project in the water-management field is the water-apportionment agreement entered into in 1969 between Canada and the Provinces of Alberta, Manitoba and Saskatchewan for the apportionment of interprovincial waters flowing east, such as the Saskatchewan River. Another is the Red River Floodway at Winnipeg, a 29-mile channel that diverts a large quantity of water from the Red River during flood periods. Construction of the floodway was started in 1962 and completed in 1969.

Departmental engineers and other experts also take part in the implementation of international and federal-provincial agreements and treaties, such as the important Columbia River Treaty between Canada and the United States, the regulation of water flow through the Great Lakes-St. Lawrence system under the aegis of the International Joint Commission, the Canada-British Columbia agreement for studies and flood control in the Lower Fraser Valley, the Canada-British Columbia Okanagan Basin agreement and others.

The best way to study and plan water management is by river basins — large regional entities that usually cut across provincial and frequently also across international boundaries. It has often been found that dams and other water works built in one province or territory have a profound and perhaps unforeseen effect on the water supply and quality in another. This has recently been the case with the W.A.C. Bennett Dam on the Peace River in northern British Columbia which has changed water levels on the Mackenzie waterway in the Northwest Territories. Basin-wide approaches embracing all the governments affected are required.

blies, eliminating the need for a rudder. It carries a complement of eleven scientists and technicians, six officers, and a crew of ten, and is based at the Canada Centre for Inland Waters.

In addition to the Canada Centre for Inland Waters, the department operates permanent and temporary laboratories and water-sampling stations all across Canada. About 550 of these stations sample the water for a wide range of pollutants, including certain organics and trace metals. The laboratories are equipped to detect pesticides, trace metals including mercury, and "nutrients" — phosphorus and nitrogen. It is these nutrients, many of them derived from household detergents, that are particularly dangerous to our lakes and rivers, by stimulating the growth of algae, which in turn deplete the water of oxygen and gradually kill off fish populations. This type of pollution should soon be a thing of the past, as the Canada Water Act permits the federal government to prohibit the production and import of household cleaning agents and water conditioners containing harmful nutrients.

Laboratory staff also work on practical means of abating pollution from mining and milling operations, and from pulp-and-paper plants. Mining companies are collaborating in such studies.

Another process receiving close scrutiny from departmental water experts is sedimentation. Sedimentation occurs naturally in all lakes and rivers, but it is often increased or altered by the intervention of man. The type and rate of accumulation of sediments — which may be sand, loam, organic particles, or chemical compounds — has an important effect on pollution, apart from altering the contour of the stream bed or lake bottom.

Fundamental work is also carried out in laboratories on the structure of water and aqueous solutions, especially those of pollutants or potential pollutants.

Water — where, when, how much, for what

Closely allied to the study of water quality is that of water quantity, the use that is made, or could and should be made, of our water resources. The subject was already touched on earlier in connection with the Canada Water Act.

The federal government often joins with provinces in

A major thrust of the department's attack on pollution is scientific. Not enough is yet known about the effect of many substances entering our lakes, rivers, and coastal waters from our mines, pulp-and-paper plants, steel smelters, urban sewage systems, agricultural land treated with fertilizers and pesticides, salt-sprayed highways, etc. If all this pollution were stopped at once much of our industry and even our normal household activities would come to a standstill, with disastrous effects on the economy. The targets for attack must therefore be selected carefully, knowledgeably, and exactly. The evidence must be plain and convincing for all — scientists, polluters, and the public at large.

It is natural that research should concentrate on those water bodies that have suffered or are endangered most — the Great Lakes (and especially shallow Lake Erie) and certain fishing streams that are tainted by mine waste.

What the Atlantic Oceanographic Laboratory is for hydrography and oceanography, the Canada Centre for Inland Waters at Burlington, Ont., is for fresh water research. The offices and laboratories of the Centre are now being built and are to be completed in stages. Ultimately the Centre will house 250 to 300 engineers and scientists and other professionals and a large support staff. It will be the base for several research vessels surveying the Great Lakes-St. Lawrence system. Several other federal government and university departments are participating in the work of the Centre.

A ship typifying the research craft needed for studying these waters is the 600-ton *Limnos* (derived from a Greek word meaning "lake"). In addition to its permanent laboratories, the ship has deck space for two portable laboratories at four sounding launches. Designed for year-round operation, the *Limnos* can work in thin ice. It is steered by turning the propeller assem-



water ignores such political boundaries. Also, the same body of water usually has many different uses — agricultural, industrial, domestic, recreational, for transportation, and fishing.

Under the new Act, the Minister of Energy, Mines and Resources may "enter into arrangements with the provinces and form joint committees for the purposes of consultation, development of programs and to co-ordinate their implementation." These may be established along national, provincial, regional or lake or river-basin lines. Where necessary, regional federal-provincial boards may be set up to take inventory of water resources; collect data on their quality, distribution and use; conduct research and undertake a variety of programs designed to conserve and develop the regional water resources to the full.

The new Act also calls for the pooling of federal-provincial resources to control and combat pollution. Joint water-quality agencies may be established in designated areas to ascertain and forecast the nature and quantity of waste plaguing a particular river or lake. These agencies, after consulting municipalities, industries and others interested, establish water-quality standards, carry out quality control, design and operate waste-treatment plants and collect fees from those who discharge waste or who benefit from agency-owned facilities or services.

Thus the cost of pollution control will be borne largely by those who use water for waste disposal; both industry and municipalities will be required to pay for waste treatment provided by the agency or install their own anti-pollution equipment. To give the agencies the necessary teeth for doing their work, the new legislation inflicts severe penalties — up to \$5,000 a day — on those who wantonly pollute water.

It is obvious that the success of the Canada Water Act depends on successful federal-provincial collaboration and the establishment and effective operation of the committees and agencies noted above.

For the prevention of possible pollution from oil wells penetrating Canada's undersea continental shelves, the department, as the federal government's arm for licensing petroleum exploration and exploitation in the Atlantic, Pacific, and Hudson Bay, is regulating the engineering of boreholes and well-casings. Canada's regulations in this field are among the most stringent in the world.

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The role of the Department of Energy, Mines and Resources in the study, use and conservation of Canada's sea lanes and water resources

J. J. Greene, Minister
J. Austin, Deputy Minister

Many federal, provincial and local agencies in Canada are concerned in one way or another with Canada's water—the sweet or fresh water in our rivers, lakes, glaciers, and in the ground; and the salt water over our continental shelves and in the sea lanes converging upon our harbors. But the most comprehensive role in the water field is being played by the Federal Department of Energy, Mines and Resources, and specifically the professional, technical and administrative staff of its Water Sector.

Their work may be divided roughly into two main categories, each of which depends on the other for advice and information: scientific research directed chiefly to the acquisition of knowledge about Canada's water in all its forms, and policy recommendations to the federal government concerning federal and federal-provincial measures in the management of water resources. Without guidance from economists and resource planners, the scientists would not be able to direct their research toward problems of national importance; and without data from the scientists the policy makers would not be able to assess the economic and social costs and benefits involved in the enactment of laws for the reduction or control of pollution, the exploration and exploitation of undersea resources, such as oil, the construction of dams, harbors, causeways, canals, dikes, irrigation schemes and the regulation of marine traffic.

Some of the Water Sector's units can look back on a long history, others are new and were created to deal with modern needs and problems. Man has always been concerned about water, and since earliest times measures were taken by agricultural and urban communities to ensure a reliable water supply and by seafarers to ensure safe navigation and shelter from storms. The quality of water, however, was usually taken for

granted, and few scholars concerned themselves with the intricate physical and chemical processes that take place in all water, fresh and salt, or the complexities of the hydrologic cycle which causes water to circulate between the sea, the atmosphere and the land. Now that modern civilization is intervening to an ever greater degree in this physical-chemical cycle it has become high time to study it as thoroughly as we have been studying our soil and our minerals, and to prevent or counteract those interferences that might injure our health and prosperity, along with those of future generations.

Ships

To support the activities of the whole Water Sector, its Marine Sciences Branch operates a fleet of ships and launches. These are based at the Atlantic Oceanographic Laboratory, Dartmouth, N.S., at the Canada Centre for Inland Waters at Burlington, Ont., and the Pacific Region Office, Victoria, B.C. These ships are equipped to carry out a wide range of hydrographic, oceanographic, limnological, geophysical and geological studies.

Hydrography

An accurate knowledge of depths is vital to safe navigation, and is an essential factor in all oceanographic and limnological investigations. The Canadian Hydrographic Service, which provides this information, traces its history back to 1883, when the Canadian government started a survey of Georgian Bay, and since 1904 it has been responsible for the charts of all Canadian coastal and inland waters.

Now a component of the Department of Energy, Mines and Resources, the Hydrographic Service uses ships and launches for sounding and surveying the waters off Canada's coasts and the major lakes and rivers used by commercial and pleasure traffic. The largest survey ship is the *Baffin*, with a displacement of 3,700 tons, landing and hangar facilities for two

helicopters, and quarters for 21 hydrographic and scientific staff and 81 officers and crew. Along with several other departmental ships, she is based at Dartmouth, N.S. Other hydrographic ships are based at Victoria, and one small but rugged survey ship is based at Tuktoyaktuk, at the mouth of the Mackenzie River.

The ships and launches designed especially for hydrographic surveying are equipped with various types of echo sounders for measuring water depths, and electronic position-finding gear.

The ultimate product of hydrographic surveys is the nautical chart, the mariner's equivalent of the topographic map. It shows in great detail the location of shoals and other underwater dangers and obstacles, various aids for position-finding—visual and electronic—compass variation, prominent landmarks, and other features of interest to seafarers. Written sailing directions supplement the chart by describing the prevailing winds and currents, the best way of approaching a particular harbor, what services are available in port, etc. Sailing directions for all of Canada's coasts, the Great Lakes and the Mackenzie waterway can be ordered from the Service. Annual chart distribution stands at about 330,000. Charts constantly need to be revised and updated because of changes in aids to navigation, new harbor construction, dredging, and the changes in maritime traffic patterns caused by the advent of new deeper-draft vessels. Special charts are also produced for pleasure craft, fishermen and national defence.

Offshore surveys of the continental shelf—the extension of continental land masses into the ocean at relatively shallow depths—are carried out on a fully integrated basis, with simultaneous readings being made of the ship's position, water depth, gravity, and total magnetic field. These enable natural-resource charts to be produced which are of great value in the exploration of the continental shelf for petroleum and natural gas. The skill of the hydrographer in accurate position-fixing far from land will become ever more important in the delimitation of exploration permits and the re-location of drill-holes.

Oceanography

The department's oceanographers, based mainly at the Atlantic Oceanographic Laboratory in Nova Scotia,

are interested in every factor affecting the behavior of the sea, the physical and chemical processes in the water, and the interaction between the sea and its land and air environment.

This type of research has important implications for marine biology—fish, shellfish, and the microscopic forms of life on which they depend for their food; for the control of pollution along our coasts; for marine geology and mineral exploration of the sea bottom; for the forecasting of the "wave climate"; and for ship and harbor construction.

Collaboration between oceanographers, marine biologists and marine geologists is close. Thus, when pollution was suspected as the cause of the death of fish in Long Harbour and Placentia Bay, Newfoundland, oceanographers worked with scientists of the Fisheries Research Board in analyzing the water and tracking down the polluting substance. Close liaison is maintained with oil companies exploring for petroleum on Canada's continental shelf, to provide the information they require on currents, bottom sediments, and other factors.

Canada's largest and most important oceanographic ship is the *Hudson*. One of the most modern research vessels in the world, she displaces 4,800 tons, is capable of cruising 15,000 miles without refuelling, is designed to withstand Arctic ice, and carries a large array of sophisticated electronic equipment for communication and position-finding. She has extensively equipped chart rooms, laboratories, and various winches for lowering water or bottom samplers, temperature gauges, underwater cameras, and other devices.

In her most extensive survey cruise—the longest ever undertaken by a Canadian research vessel—the *Hudson* traversed the length of the Atlantic and Pacific oceans in 1970, making numerous scientific observations en route. Outstanding among these were the first

direct measurements of currents in Drake passage—the wide strait between South America and Antarctica—regarded by oceanographers as "the pulse of the world's currents."

Oceanography is a relatively new science, and much effort is being devoted to the design and development of new instrumentation. Even more than other research units, oceanography prizes technical ingenuity and dexterity. One piece of equipment designed and put to work by the oceanographers at the Atlantic Oceanographic Laboratory is a "stable platform" for measuring the effect of wind on the sea surface. Very little was known until recently about this subject, because it is extremely difficult to place a group of instruments at the sea surface that would not be disturbed or destroyed by wind, waves, or ice, or affect the behavior of the water. The stable platform developed by the oceanographers carries instruments on a mast that extends 20 feet above water and is held steady by thirteen 25-ton anchor blocks. It remains practically motionless even in very heavy seas. Measurements made by the instruments on the platform, transmitted by radio telemetry to a shore station, make it possible to determine the "wave climate" of the area in question—information of great practical value to marine engineering.

Another interesting type of investigation concerns the processes in sea ice, and between ice and water. At first glance, nothing seems quite as solid and inert as sea ice. But oceanographers from the Frozen Sea Research Group who succeeded in cutting a six-ton block out of an icesheet at Cambridge Bay, Victoria Island, found that during aging of the ice numerous tiny veinlets were draining salt from the ice into the sea. This process sets up intricate physical interactions between sea and ice which are not yet fully understood. With the Canadian Arctic becoming ever more impor-

tant for resource development and maritime traffic, knowledge of ice formation, behavior and decay is of primary importance.

Seafarers have known since ancient times that there are extensive surface currents in the sea, the best known of which is probably the Gulf Stream. But oceanographers have found that vast water masses also circulate vertically—in fact, in every imaginable direction, with a complex interplay of temperature, salt content, specific gravity, and biological factors. Research into this subject is being carried out throughout the North Atlantic and along the Pacific Coast.

Canada boasts the world's largest tides—in the Bay of Fundy, where the difference between high and low water may reach 53 feet. Tidal forecasting is a highly complex business, and the analysis and prediction of tides has been greatly simplified by the use of electronic computers. Each year tide and current tables are published by the Canadian Hydrographic Service.

Detection and prevention of pollution

One of the most widely debated issues of recent years is the pollution which our industrial civilization inflicts on our natural environment—air, soil, and water. Since the Department of Energy, Mines and Resources is the primary federal agency for water research and water planning it was natural that it should be drawn deeply and vigorously into the efforts being made to control and to counteract this modern menace. At the same time, it must be borne in mind that the department, and even the federal government as a whole, is only one of several levels of legislative and executive authority and numerous specialized agencies active in the natural-resource field in Canada. It cannot act unilaterally on many problems arising from water pollution. It can and does, however, provide guidance and leadership for all of Canada in the scientific and administrative attack on water pollution.

One of the main instruments developed largely in the department's Water Sector for the management of Canadian water resources and the prevention and reduction of water pollution is the new Canada Water Act. The Act rests on the realization that while jurisdiction over fresh water in Canada is in many respects divided between federal and provincial authorities,

